

# AI-Powered USB Handbook

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USB

*AI-Powered USB Handbook Team*

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# 1. AI-Powered USB Handbook

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AI-Powered USB Handbook			
AI-Powered USB Handbook Type-C	USB	USB 3.2 Gen 2x2	Thunderbolt 4 ( 4)

## 1.1

---

- -
- USB - USB
- USB -
- Thunderbolt -
- - USB PD
- -

## 1.2

---

- 
- 
- 
- 

## 2. 1 (Introduction)

---

### 2.1

---

USB (Universal Serial Bus) Type-C			USB	USB 3.2 Gen 2x2
AI-Powered USB Handbook	USB	AI		

### 2.2

---

	4	USB4		
		USB		

### 2.3

---

1.
2. USB 1.0 USB4
3. Intel Thunderbolt USB
4. USB PD PPS
5.

### 3. 2 :USB (USB Connector Types)

USB

#### 3.1 USB

##### 3.1.1

USB 1996 Type-A Type-B

- MP3
- 
- 
- 

[!IMPORTANT] 2024 USB Type-C iPhone 15 Type-C

##### 3.1.2 USB

```

timeline
    title USB
    1996 : USB 1.0 : Type-A / Type-B : 1.5Mbps ( )
    1998 : USB 1.1 : 12Mbps ( )
    2000 : USB 2.0 : 480Mbps ( ) : Type-A/B
    2000 : Mini USB : Mini-A / Mini-B :
    2007 : Micro USB : Micro-A / Micro-B : <br> Mini USB
    2008 : USB 3.0 : 5Gbps ( ) : Type-A/B <br>
    2013 : Micro USB 3.0 : :
    2014 : USB Type-C : <br> :
    2017 : USB 3.2 : 20Gbps : Type-C
    2019 : USB4 : 40Gbps : Type-C
    2024 : Type-C :
```

##### 3.1.3

Type-A	-	Type-A	1996	-	-	USB 3.2	Type-A
Micro USB	-	2007-2020	-	Micro USB	-		Type-C
Type-C	-	2014	Lightning	-	2024	-	

### 3.2 USB Type-A

USB

- 
- 12mm × 4.5mm
- 1,500

3.2.1

USB 2.0 Type-A 4

1	VBUS	(+5V)
2	D-	
3	D+	
4	GND	

USB 3.0/3.1/3.2 Type-A 9

USB 2.0 4 5

5	StdA_SSRX-	
6	StdA_SSRX+	
7	GND_DRAIN	
8	StdA_SSTX-	
9	StdA_SSTX+	

[!NOTE] USB 3.0+ 5 USB 2.0 4 USB 3.0 USB 2.0 4

3.2.2

USB-IF

/	USB 2.0	480Mbps
	USB 3.0/3.1 Gen 1	5Gbps
Teal	USB 3.1 Gen 2	10Gbps
	USB 3.2 /	20Gbps
	/	BC 1.2





[!TIP] USB 3.0+ / USB 2.0

3.2.3

USB			
USB 2.0	500mA	2.5W (5V 0.5A)	
USB 3.0	900mA	4.5W (5V 0.9A)	
USB BC 1.2	1.5A	7.5W (5V 1.5A)	(DCP)
USB 3.1/3.2	3A	15W (5V 3A)	

[!WARNING] Type-A                      USB PD                      >15W                      **Type-C**

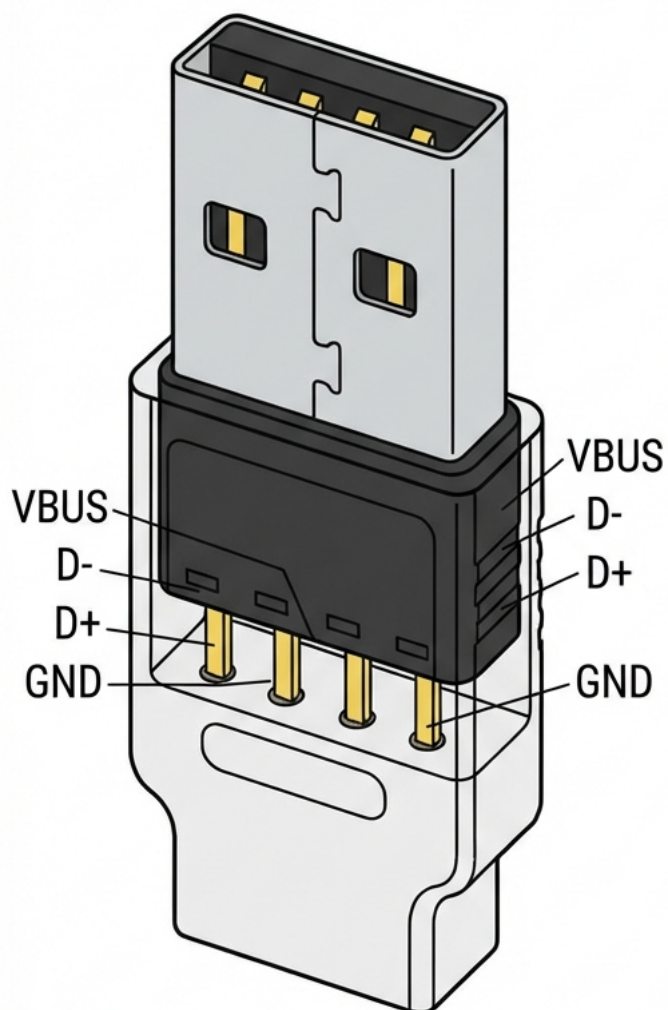
3.2.4

                         -                      -                      USB

- Type-A                      Type-B    Micro USB    Type-C

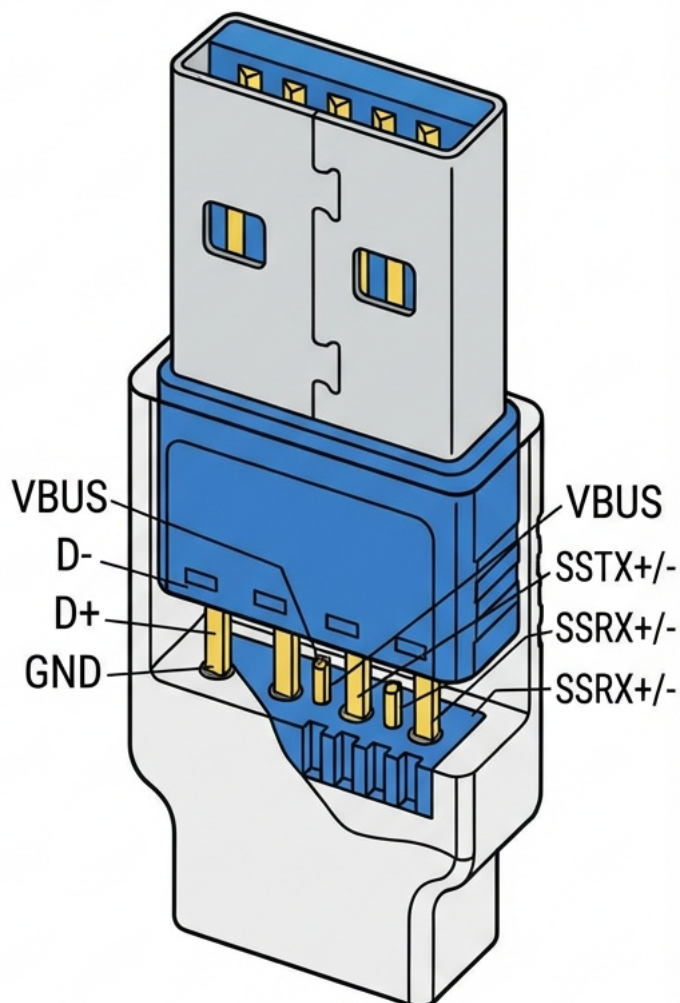


## USB 2.0 Type-A



## USB 2.0 Type-A

## USB 3.0 Type-A (SuperSpeed)



## USB 3.0 Type-A (SuperSpeed)

### 3.3 USB Type-B

Type-B

Type-A

Type-B

#### 3.3.1 Type-B

##### Standard-B

- 
- 8mm × 7mm
- 4 USB 2.0 9 USB 3.0
-

Mini USB Type-B

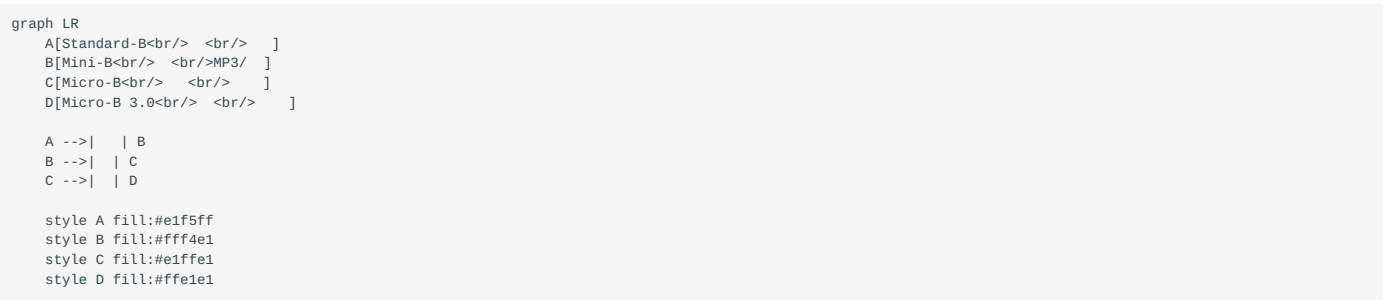
- Standard-B
- 7mm × 3mm
- 5
- MP3 GPS
- Micro USB

Micro USB Type-B

- 
- 7mm × 1.8mm
- 5 USB 2.0
- 2007-2020
- Type-C

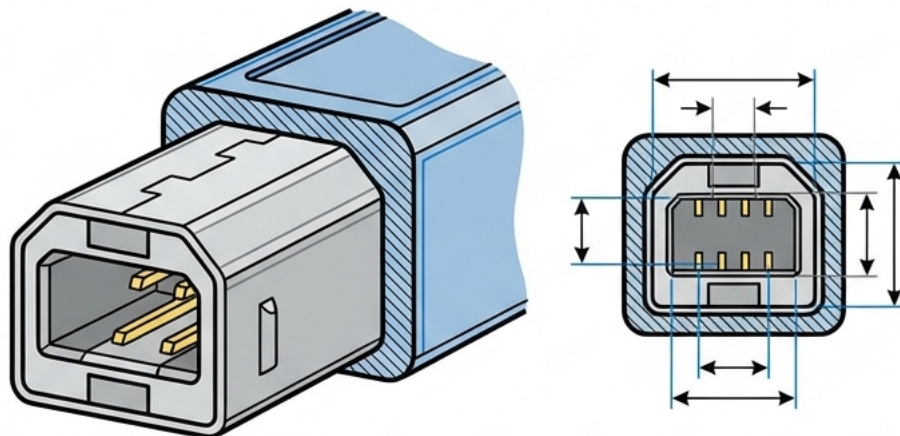
Micro USB 3.0 Type-B

- Micro USB 2.0
- 12mm × 1.8mm
- 10 5 USB 2.0 + 5 USB 3.0
- Elements Backup Plus Galaxy Note 3/S5
- Micro USB 2.0

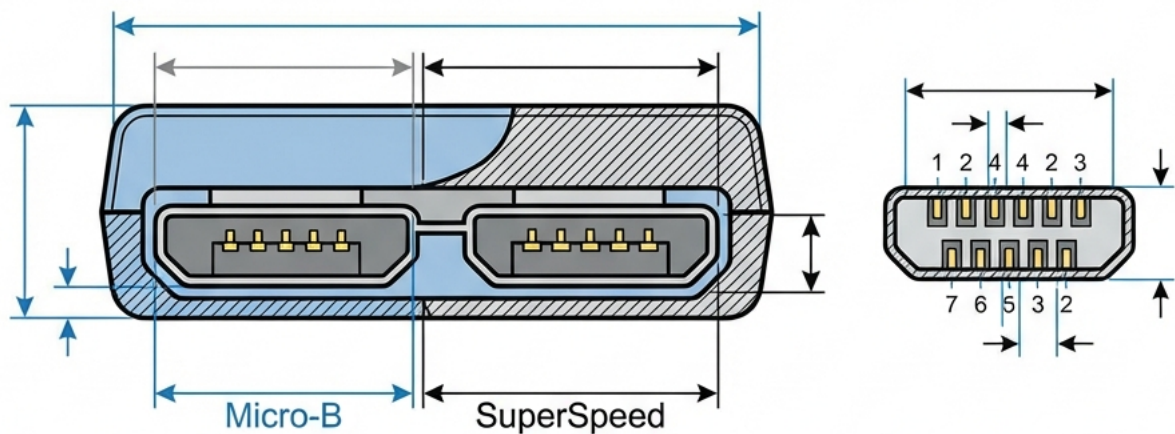


3.3.2 Type-B

- Type-B USB " " Type-B Type-A
- Standard-B
- **Type-C** Type-C



USB Standard-B  
(Printer)



USB Micro-B SuperSpeed  
(External HDD)

### 3.4 Mini USB & Micro USB

#### 3.4.1 Mini USB

- 2000
- Standard-B
- 5

- 
- **Mini-A**
- **Mini-B**
- **Mini-AB**            OTG
- MP3                GPS
- **2007        Micro USB**

3.4.2 Micro USB

Micro USB 2.0 Type-B

5





1	VBUS	(+5V)
2	D-	
3	D+	
4	ID	OTG
5	GND	

- ID                    **OTG (On-The-Go)**                    - ID                    U                    - ID                    -                    7mm × 1.8mm

Mini USB                    -                    10,000

OTG (On-The-Go)




OTG

-  -  -  -  -                    /                    -

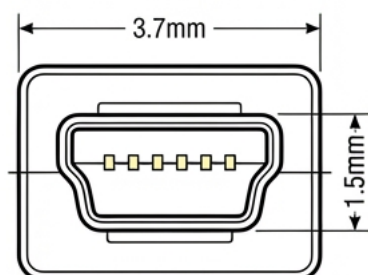
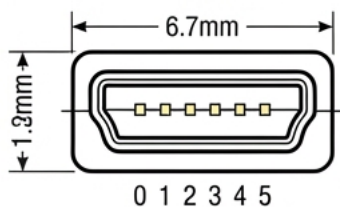
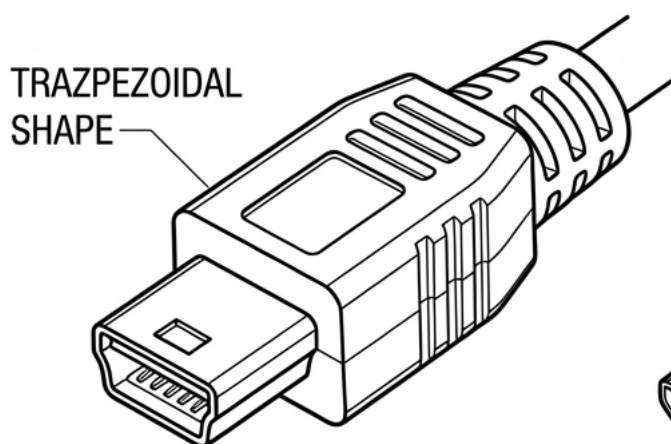
-                    **Micro USB OTG**                    Micro USB                    Type-A                    - ID                    -                    OTG

3.4.3 Micro USB

Micro USB

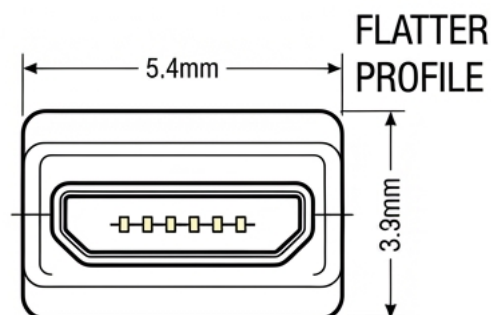
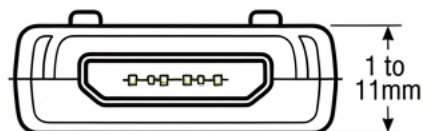
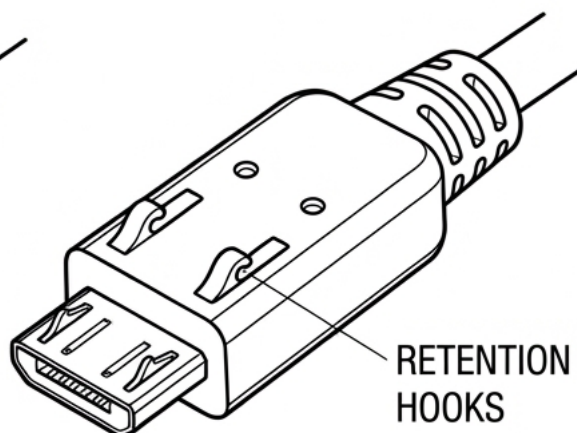
1.                    -                                          -
2.                    -                    10,000                    -
3.                    -                    Micro USB                    **USB 2.0** 480Mbps                    -                    4K                    - Micro USB 3.0                    5Gbps
4.                    -                    7.5W (5V 1.5A, BC 1.2) -                    30W+
5.                    -                    -                    Alt Mode
- [!WARNING]                    Micro USB                    -                    -                    -

## MINI USB



## MINI USB

## MICRO USB



## MICRO USB

### 3.5 USB Type-C

- 
- 8.4mm × 2.6mm
- 10,000 Micro USB
- 2014

[!IMPORTANT] **Type-C**

Type-C

USB 2.0

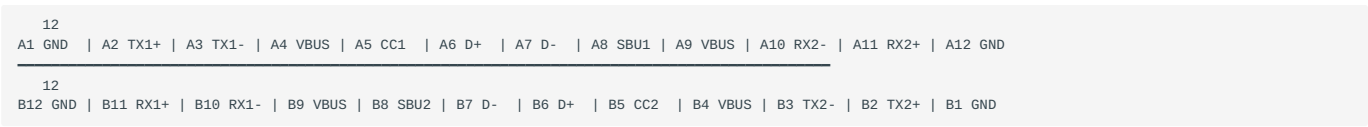
4 (40Gbps)

3.5.1 Type-C

1.
2. + + +
3. 240W (USB PD 3.1)
4. 40Gbps (USB4 / Thunderbolt 4)
5.
6.

3.5.2 Type-C 24

Type-C 24



	8	VBUS (A4, A9, B4, B9) GND (A1, A12, B1, B12)	240W	
USB 2.0	4	D+ (A6, B6) D- (A7, B7)	USB 2.0	480Mbps
USB 3.x/4	8	TX1+/- (A2, A3) RX1+/- (B10, B11) TX2+/- (B2, B3) RX2+/- (A10, A11)	TX/RX	5-40Gbps
	2	CC1 (A5) CC2 (B5)	PD	
	2	SBU1 (A8) SBU2 (B8)	Alt Mode	

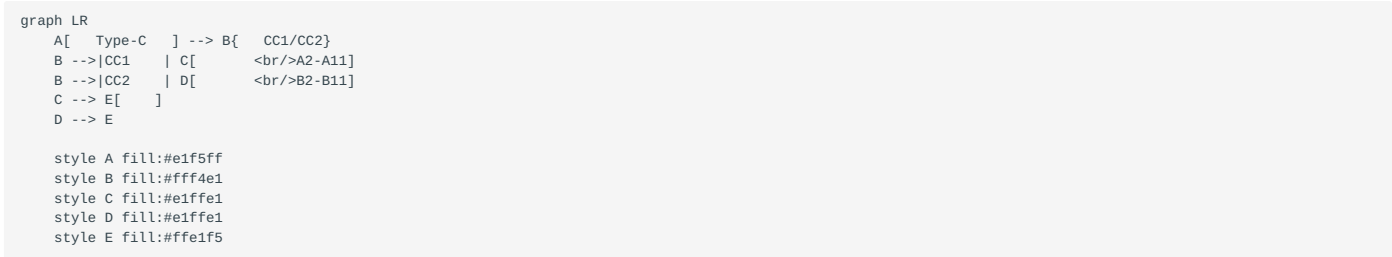
[!NOTE] Type-C

3.5.3 CC

CC

CC (Configuration Channel) Type-C

1.
2. CC1 CC2
3. " "
4. (DRP: Dual-Role Power)
5. Source Sink
6. Type-C
7.
8. Source CC
9. Default (500mA/900mA) 1.5A 3A
10. USB PD
11.
12. PD Source\_Capabilities Request



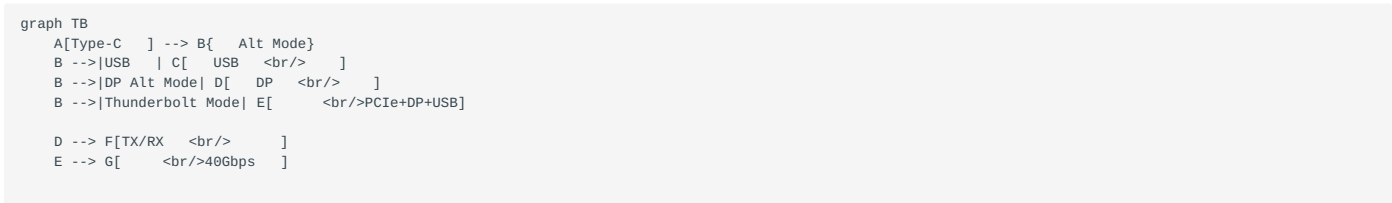
3.5.4 Alt Mode Type-C

Alternate Mode ( ) Type-C USB

Alt Mode

1. DisplayPort Alt Mode - Type-C - - / - Type-C HDMI/DP - 8K@60Hz DP 2.0 - USB 3.x TX/RX
2. Thunderbolt 3/4 Alt Mode - PCIe DisplayPort USB - 40Gbps - (eGPU) - SSD - Thunderbolt 3/4 Type-C
3. HDMI Alt Mode - HDMI - Type-C HDMI
4. Audio Adapter Accessory Mode - - Type-C 3.5mm - SBU1/SBU2

Alt Mode



```
style A fill:#e1f5ff
style B fill:#fff4e1
style C fill:#e1ffe1
style D fill:#ffe1e1
style E fill:#ffe1ff
```




[!TIP]    Type-C    Alt Mode    "    " "DP Alt Mode"

3.5.5    Type-C vs    Type-C

Type-C    "    "

USB 2.0	USB 3.x	Type-C	Thunderbolt 4
480Mbps	5-20Gbps	5-40Gbps	40Gbps
15W	100W	240W (PD 3.1)	100W
✗	✗	✓ (DP Alt Mode)	✓ (DP 2.0)
✗	✗	✗	✓
💰	💰💰	💰💰💰	💰💰💰💰
	/PC	/	/Mac

"    "

-    **USB 2.0**    **Type-C**    iPhone 15    -    USB 3.x    PHY    -    \$1-2    -    480Mbps    -    **Type-C**    -  
DP Mux    -  
[!WARNING]     Type-C    -     DeX    -     Type-C    -    USB  
PD

3.5.6 Type-C    Thunderbolt

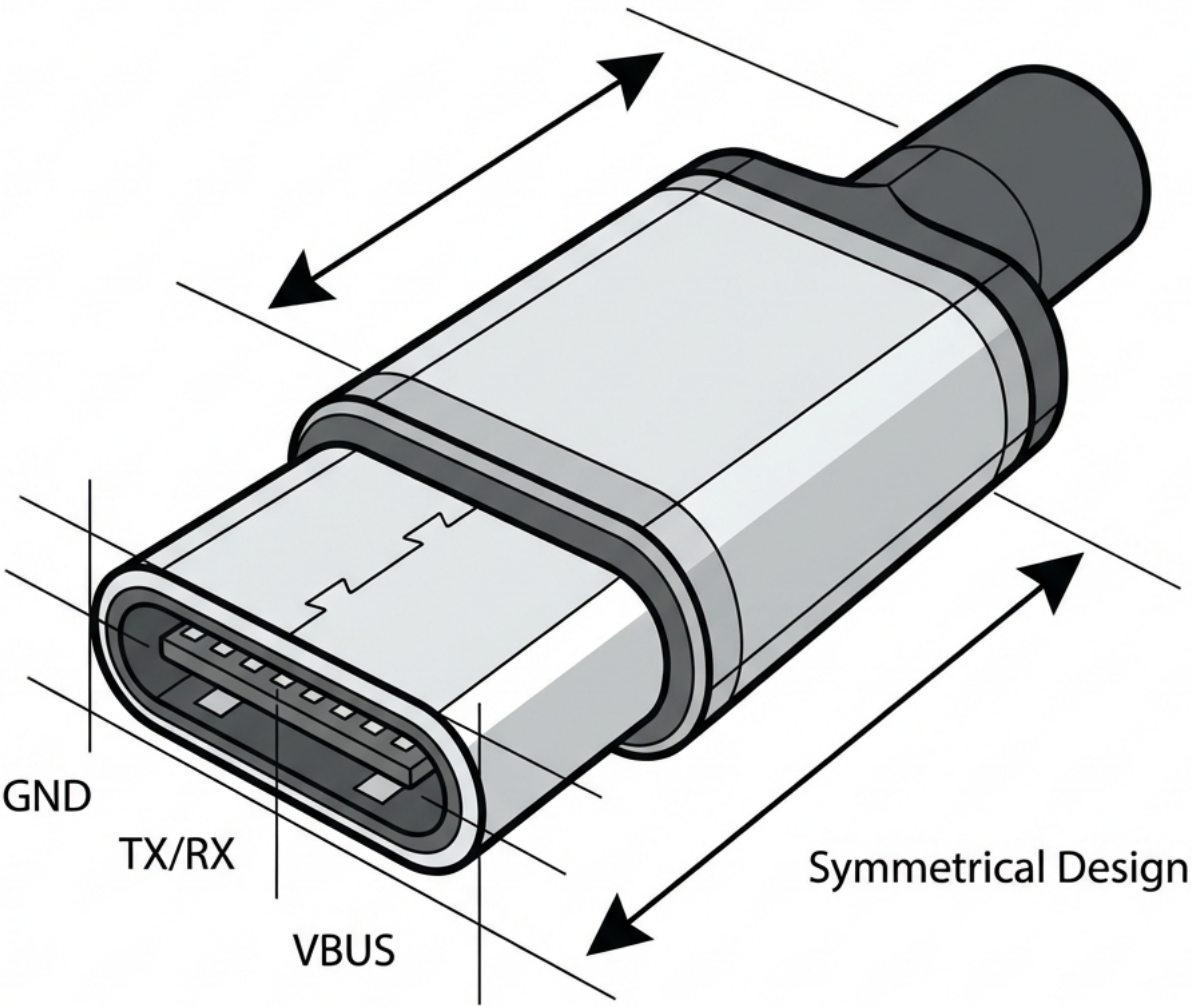
**Thunderbolt 3/4**    **Type-C**    **Type-C ≠ Thunderbolt**

USB Type-C	Thunderbolt 3/4
USB2.0~USB4 (480Mbps-40Gbps)	40Gbps
+	+    +    +PCIe
USB-IF	Intel
USB	⚡

Thunderbolt

        -    Thunderbolt 3/4    "3"  "    MacBook    Thunderbolt  
-    eGPU    -    40Gbps    -    Daisy Chain





3.6 USB

3.6.1

	(mm)				
Type-A	12×4.5	4/9	20Gbps (USB 3.2)	15W	1,500
Standard-B	8×7	4/9	20Gbps		1,500
Mini USB	7×3	5	480Mbps	2.5W	5,000
Micro USB	7×1.8	5	480Mbps	7.5W	10,000
Micro USB 3.0	12×1.8	10	5Gbps	7.5W	10,000
Type-C	8.4×2.6	24	40Gbps (USB4)	240W (PD 3.1)	10,000

[!TIP] " " " " "

3.7

3.7.1 USB

1. - Type-A - Type-C - Micro USB
2. Type-A - USB 3.0/3.1 Gen 1 (5Gbps) / USB 2.0 (480Mbps) - USB 3.2 -
3. - SS (SuperSpeed) USB 3.0 (5Gbps) - SS 10 SS+ USB 3.1 Gen 2 (10Gbps) - SS 20 USB 3.2 (20Gbps) - ⚡ Thunderbolt 3/4 (40Gbps) - USB-IF

Type-C Marker

✗

⚠

✓

100W 5A - Thunderbolt

USB 2.0

480Mbps -

USB 3.x

✓

E-

1. SS 5A Thunderbolt 2. USB POWER-Z 3.

3.7.2 FAQ

- Q1: Type-C

- A: Charge-Only Cable

" "
- Q2: Type-C Type-A

- A: - Type-A USB 3.2: 20Gbps - Type-A 15W USB PD -

Type-C Alt Mode
- Q3: Type-C

- A: - " " "DP Alt Mode" - " USB PD" - "USB 3.x/4" -
- Q4: Micro USB OTG

U - A: OTG ID " " U Micro USB ID
- Q5: Type-C

- A: - \$ 10 \$ \$ USB 2.0 - \$ \$ \$ USB 3.x + - 100+ +E-

Marker+USB-IF \$ \$ \$ \$ 200+ Thunderbolt 40Gbps
- Q6: Type-C PD

- A: 1. USB PD 2. USB PD 3. 3A 5A E-

Marker 4.



/ - 1× Type-A (USB 3.2) - 3× Type-C ( 2 Thunderbolt 4) - 4K - 100W PD

- 1 / - GaN 30-67W - PD + PPS - Anker Baseus
- 2 - GaN 100-150W - 2C1A 3C - - Anker 747 (150W) Baseus 160W
- 3 + - 100W+ - 65W - GaN

3.10

	Reversible Plug	Type-C
Alt Mode	Alternate Mode	Type-C USB /
OTG	On-The-Go	U
CC	Configuration Channel	Type-C PD
SBU	Sideband Use	Type-C Alt Mode
DRP	Dual-Role Power	Type-C
E-Marker	Electronically Marked Cable	
GaN	Gallium Nitride	
eGPU	External Graphics Processing Unit	Thunderbolt
Daisy Chain		Thunderbolt 6
PHY	Physical Layer Chip	
DP Mux	DisplayPort Multiplexer	Alt Mode

3.11

3.11.1

- [USB-IF](#)
- [USB Type-C](#)
- [Thunderbolt](#)

3.11.2

- [USB-IF](#)
- 

3.11.3

- **POWER-Z** USB
- **ChargerLAB KT002**
- **USB Device Tree Viewer** USB Windows

• **System Information** Mac      USB/Thunderbolt

.....			
[!NOTE] USB	USB4 Version 2.0 (80Gbps)	PD	USB-IF

## 4. 3 USB (USB Transfer Protocols)

USB USB-IF (USB )

### 4.1

- **USB 1.0 / 1.1:**
- **Low Speed:** 1.5 Mbps ( )
- **Full Speed:** 12 Mbps
- **USB 2.0:**
- **High Speed:** 480 Mbps “ ”

### 4.2 USB 3.x

	(2013)	(2019)			
USB 3.0	USB 3.1 Gen 1	USB 3.2 Gen 1	USB 3.0 / 5Gbps	5 Gbps	8b/10b
N/A	USB 3.1 Gen 2	USB 3.2 Gen 2	USB 3.1 / 10Gbps	10 Gbps	128b/132b
N/A	N/A	USB 3.2 Gen 2x2	USB 3.2 / 20Gbps	20 Gbps	128b/132b

USB 3.2 Gen 2x2 Type-C Type-C

### 4.3 USB4

USB4 Intel Thunderbolt 3

- **USB4 Gen 2x2:** 20 Gbps
- **USB4 Gen 3x2:** 40 Gbps ( )
- 
- **(Tunneling)** (USB 3.2) (DisplayPort) PCIe
- USB 3.2 USB 2.0 Thunderbolt 3

## 5. 4 Thunderbolt ( ) (Thunderbolt Technology)

Thunderbolt Intel Apple “ ” “ ”

### 5.1 Thunderbolt 3 ( 3)

- USB Type-C
- 40 Gbps
- PCIe x4 ( ) DisplayPort ( 5K/8K ) USB
- 3 USB 3.x USB

### 5.2 Thunderbolt 4 ( 4)

4 40 Gbps

#### 5.2.1 4 vs 3

- |                |   |                |                    |          |               |     |
|----------------|---|----------------|--------------------|----------|---------------|-----|
| 1. <b>PCIe</b> | 4 | PCIe           | <b>32 Gbps</b> ( 3 | 16 Gbps) | (eGPU)        | SSD |
| 2.             | 4 | <b>4K</b>      | <b>8K</b> ( 3      | 4K)      |               |     |
| 3.             |   | Intel VT-d DMA | DMA                |          |               |     |
| 4.             | 4 | <b>(Hub)</b>   | 1 3                | 3        | (Daisy Chain) |     |

### 5.3 Thunderbolt vs USB4

- USB4 3
- 
- **USB4** “ ” 20Gbps 40Gbps PCIe
- **Thunderbolt 4** “ ” 40Gbps PCIe Intel
- **Thunderbolt 4** **USB4** “ ”

## 6. 5 (Charging & Power Delivery)

USB 2.5W (5V 0.5A) 240W

### 6.1

#### 6.1.1 USB BC 1.2 (Battery Charging)

USB BC 1.2 USB-IF 2010

- 7.5W (5V 1.5A)
- D+/D-
- 
- **SDP (Standard Downstream Port)** USB 500mA
- **CDP (Charging Downstream Port)** + 1.5A
- **DCP (Dedicated Charging Port)** 1.5A
- 

### 6.2

#### 6.2.1

- 2010
- **USB 2.0** USB **2.5W** (5V 0.5A) 4-6
  - **USB BC 1.2** 7.5W (5V 1.5A)
  - USB PD 1.0 2012 2016 PD 3.0
  - 
  - " 5 2 "
  - 
  - 2013-2016 USB PD
- OPPO " "

[!IMPORTANT]

#### 6.2.2

```

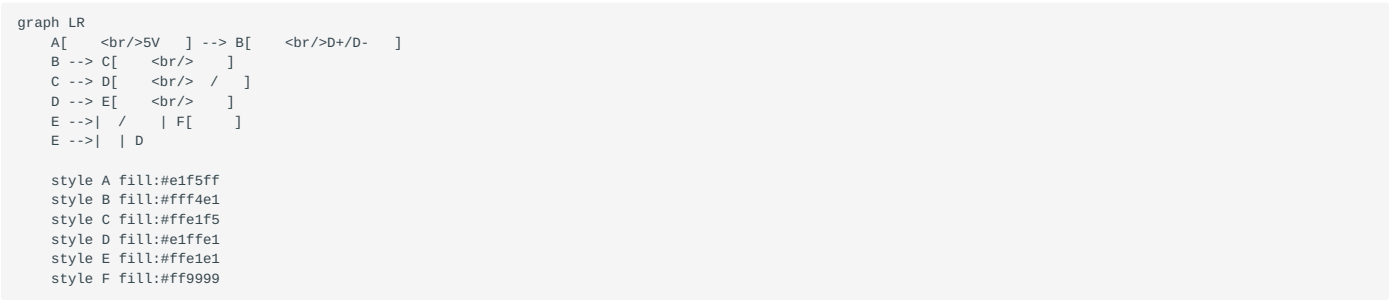
timeline
    title
    2010 : USB BC 1.2 (7.5W) :
    2012 : USB PD 1.0 : PD <br>
    2013 : QC 1.0 (10W) :
    2014 : QC 2.0 (18W) :
    : OPPO VOOC (20W) :
    2015 : FCP (18W) :
    : PE+ : MTK
    2016 : QC 3.0 : 200mV
    : SCP (22.5W) : <br>
    : USB PD 3.0 :
    : vivo (22.5W)
    2017 : PE 3.0 (30W)
    : QC 4 : USB PD
    2018 : OPPO SuperVOOC (50W) :
    : (27W)
    : QC 4+
```



2019	:	OPPO SuperVOOC 2.0 (65W)	
	:	SCP 2.0 (40W)	
2020	:	QC 5 (100W+) :	PD
	:	(120W)	
2021	:	OPPO 125W/240W :	
	:	(210W)	
	:	vivo (200W)	
2023	:	Type-C :	

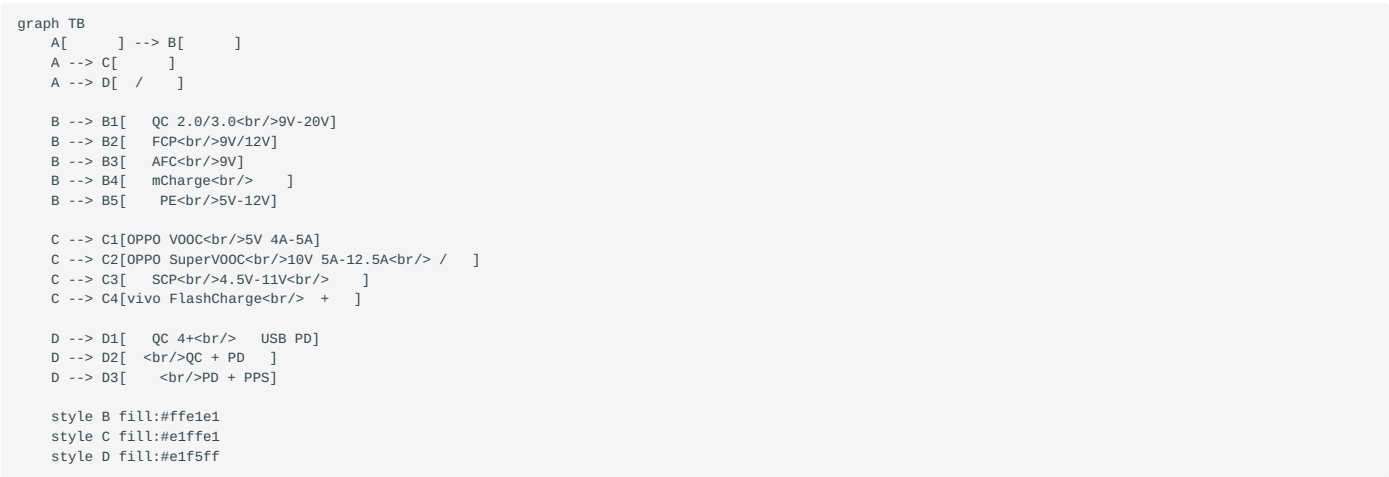
6.2.3

Handshake Protocol



1. 5V
2. D+/D-
3.
4. /
5.

[!NOTE] D+/D- USB " "



6.2.4 Quick Charge (QC)

Quick Charge Android

QC 1.0 (2013)

- 10W (5V 2A)

- 
- 

QC 2.0 (2014)

QC 2.0

- 18W
- 
- Class A: 5V 9V 12V
- Class B: 5V 9V 12V 20V
- 3A
- D+/D-
- 5V D+ = D- = 0.6V
- 9V D+ = 3.3V, D- = 0.6V
- 12V D+ = 0.6V, D- = 0.6V
- 20V D+ = 3.3V, D- = 3.3V Class B

QC 3.0 (2016)

QC 3.0

- 18W 22W
- 3.6V - 20V
- 200mV QC 2.0
- 
- 
- 38% QC 2.0
- 
- QC 2.0

QC 4 / QC 4+ (2017-2018)

QC 4/4+ USB PD

- 28W (QC 4) 100W (QC 4+)
- 
- USB PD 3.0 PD
- PPS (Programmable Power Supply)
- INOV (Intelligent Negotiation for Optimum Voltage)
- QC USB PD
- 

QC 5 (2020)

- 100W+
- 98%

•	USB PD	QC			
[!IMPORTANT] QC 4                      USB PD                      QC 4+                      PD                      iPhone   MacBook					
<hr/>					

6.2.5 OPPO VOOC

OPPO	VOOC
------	------

VOOC (2014)

•	20W				
•	/	5V	4A		
•					
•		QC	5V	4A-5A	
•		7	Micro-USB	5	2
•					
•		MCU (	)		
•					
•					
•					
•					

SuperVOOC (2018)

SuperVOOC			
•	50W		
•	/	10V	5A
•			
•		2000mAh	
•	10V		5V
•	5V	10V	5A
•			

SuperVOOC 2.0 (2019-2020)

•	65W
•	/ <b>10V 6.5A</b>
•	OPPO Find X    Reno

125W / 240W (2021-)

OPPO	- 125W	10V 12.5A	- 240W	24V 10A
[!WARNING] VOOC                      OPPO                      Type-C                      VOOC				

6.2.6 FCP / SCP

FCP (Fast Charge Protocol, 2015)

- 18W
- 9V / 12V
- 2A
- D+/D-
- 

SCP (SuperCharge Protocol, 2016)

- SCPVOOC
- - SCP 1.0 22.5W (5V 4.5A 4.5V 5A)
  - SCP 2.0 40W (10V 4A )
  - SCP 3.0 66W (11V 6A)
  - 
  - 
  - 
  - 
  - FCP

[!NOTE] FCP SCP SCP FCP FCP FCP SCP

6.2.7 Pump Express (PE / PE+)

Pump Express Plus (PE+, 2015)

- 18-24W
- 5V - 12V
- 
- D+/D-
- 
- 
- QC

Pump Express 3.0 (PE 3.0, 2017)

- 30W
- 3V - 6V
- USB Type-C Type-C
- 20 70%

USB PD PE

(2016)

- 22.5W
- / 9V 2.5A 5V 4.5A
- 

- 44W 55W 66W 120W 200W
- 
- vivo

### 6.2.9

(Mi Turbo Charge)

<b>QC 3.0 (2016-2017) -</b>	<b>18W (9V 2A / 12V 1.5A) -</b>	<b>QC 3.0 -</b>	<b>5</b>	<b>Note 2 -</b>
-----------------------------	---------------------------------	-----------------	----------	-----------------

<b>27W</b>	<b>(2018) -</b>	27W (9V 3A) -	QC 4/QC 4+	USB PD -	MIX 2S	8 -	QC PD
------------	-----------------	---------------	------------	----------	--------	-----	-------

**(2019-2020)**

<b>33W</b>	-	33W (11V 3A) -	-	-	-	-	9 Pro	Redmi K20 Pro
------------	---	----------------	---	---	---	---	-------	---------------

**50W** - 50W (10V 5A) - + USB PD - 25W - 10 Ultra

**67W** - 67W (11V 6.1A 20V 3.35A) - - 11V 6.1A - **USB PD** 20V 3.35A - -  
2250mAh - 33.5W - 11 Redmi K40 Pro

**(2021-)**

<b>120W</b>	-	120W (20V 6A	12V 10A) -	-	12V 10A	- <b>PD</b>	20V 6A	-	+	-
2500mAh	- MTW	-	15	4500mAh	-	11 Pro/Ultra	12 Pro			

**210W** (2023) - **210W** (20V 10.5A) - - **100W** + - **15C** 2-3C - **MTW** - 4  
50% **9** 4900mAh - Redmi Note 12

-	- <b>USB PD</b>	iPhone MacBook	- <b>QC</b>	QC 3.0/4+
---	-----------------	----------------	-------------	-----------

/

- 29/40 -

- 34 - 80%

		PD	QC
120W	120W	65W PD	18W QC 3.0
67W	67W	45W PD	18W QC 3.0
PD	27W-45W PD	PD	QC

[!TIP]

[!NOTE] 67W USB PD

6.2.10 (mCharge)

- 18W 24W 36W
- QC
- 

6.2.11 AFC (Adaptive Fast Charging)

- 15W 18W
- 9V
- 1.67A (15W) 2A (18W)
- D+/D-
- QC 2.0 9V

[!TIP] USB PD + PPS AFC

6.3

QC 2.0/3.0	18W		
QC 4+	100W	USB PD	PD
VOOC/SuperVOOC	20-240W	OPPO/OnePlus/realme	
FCP	18W	/	
SCP	22.5-66W	/	
PE/PE+	18-24W	MTK	
AFC	15-18W	QC	

6.4

6.4.1

- 
- 5V 1A/2A
- 
- QC 2.0/3.0 9V
- QC + FCP

6.4.2

- VOOC
- 
- 

6.4.3 USB PD

[!IMPORTANT]		USB PD 3.0	PPS	Type-C	
-	QC 4+	USB PD -	PD -	PD + PPS - <b>OPPO/</b>	PD

6.4.4

- 1.
- 2.
3. USB PD USB PD
- 4.

6.5 USB PD (Power Delivery)

USB PD	USB-IF	Type-C
--------	--------	--------

6.5.1 USB PD

- ✗
  - ✗
  - ✗
  - ✗
- USB PD

6.5.2 USB PD

D+/D-	USB PD	CC	Configuration Channel
-------	--------	----	-----------------------

CC

1. Type-C
2. Source Sink
3. CC

4. PD

PD

```
sequenceDiagram
    participant C as <br/>(Source)
    participant D as <br/>(Sink)

    Note over C,D:
    C->>D: 1. (CC )
    C->>D: 2. 5V

    Note over C,D:
    C->>D: 3. Source_Capabilities<br/>( )
    Note right of D: : 5V/3A, 9V/3A,<br/>15V/3A, 20V/5A

    D->>C: 4. Request<br/>( 20V 3A)

    C->>D: 5. Accept<br/>( )

    Note over C,D:
    C->>D: 6. PS_RDY<br/>( )
    C->>D: 7. 20V 3A

    Note over C,D:
    D->>C: Request<br/>
```

1. Type-C CC
2. 5V
3. Source\_Capabilities /
4. Request
5. Accept Reject
6. PS\_RDY Power Supply Ready
7.

[!IMPORTANT] USB PD " " D+/D- " " PD



6.5.3 PD

USB PD		CC	
Source_Capabilities	Source → Sink		
Request	Sink → Source		
Accept	Source → Sink		
Reject	Source → Sink		
PS_RDY	Source → Sink		
Get_Sink_Cap	Source → Sink		
Soft_Reset	Both	PD	
Hard_Reset	Both	5V	

6.5.4

PD 2.0 / 3.0 (2016-2018)

- 100W (20V 5A)
- 
- 5V
- 9V 12V 15V 20V
- 5A E-Marker
- 
- - 45W 5V/3A, 9V/3A, 15V/3A, 20V/2.25A - 65W 5V/3A, 9V/3A, 15V/3A, 20V/3.25A - 100W 5V/3A, 9V/3A, 15V/3A, 20V/5A

PD 3.1 (2021)

- 240W (48V 5A)
- EPR (Extended Power Range)
- 28V 36V 48V
- 
- EPR

6.5.5 PPS (Programmable Power Supply)

PPS USB PD 3.0

PPS			
PD	5V 9V 15V 20V	- 9V 4.2V -	9V → 4.2V -

PPS

- 3.3V - 21V PD 3.0 PPS
- 20mV 0.02V
- 

```
graph LR
    A[ PD<br/>9V ] -->| B[4.2V ] |
    C[PPS<br/>4.2V ] -->| D[4.2V ] |

    style A fill:#ffe1e1
    style B fill:#fff4e1
    style C fill:#e1ffe1
    style D fill:#e1ffe1

    Note1[ <br/> ]
    Note2[ <br/> ]
```

PPS

- ⚡
- 🔌
- 📶 5-10%
- 📱

PPS

PPS

PPS		
0-30%	3.6V	3.8V
30-70%	3.9V	4.1V
70-90%	4.1V	4.3V
90-100%	4.3V	4.4V

[!NOTE] " 2.0" "PD " PPS iPhone 15 Pro PPS

6.5.6 USB PD vs

USB PD		
✓	USB-IF	✗
✓		✗
CC		D+/D- /
		" "
	240W (PD 3.1)	240W (OPPO)
✓ PPS	20mV	QC 3.0 200mV
✓		
✓		✗
✓		⚠

- PD
1.

2024

USB-C
2.

PPS

PD
3.

PD
4.

[!IMPORTANT]

OPPO

USB PD

"

"

"

"

6.6 (E-Marker )

Type-C

- 3A

C-to-C

60W (20V 3A)
- 5A

E-Marker

"

5A

"

100W (20V 5A)
- EPR

PD 3.1

240W

6.6.1 E-Marker

```
graph LR
    A[ ] -->|CC| B[ <br/>E-Marker ]
    B -->| | C[ ]

    B --> D[ :<br/>1. 5A<br/>2. <br/>3. <br/>4. ]

    style A fill:#ffe1e1
    style B fill:#e1f5ff
    style C fill:#e1ffe1
    style D fill:#fff4e1
```

[!WARNING]

3A

100W

60W

6.7

6.7.1 1

66W (SCP)	Mate 40 Pro	66W	65W	SCP	✓
66W (SCP)	11	66W	27W	USB PD	⚠ PD
66W (SCP)	iPhone 14 Pro	66W	27W	USB PD	⚠ PD iPhone
OPPO 65W (VOOC)	OPPO Find X5 Pro	65W	65W	SuperVOOC	✓
OPPO 65W (VOOC)	11	65W	10W		✗
OPPO 65W (VOOC)	iPhone 14 Pro	65W	0W		✗ VOOC PD
120W	12 Pro	120W	120W		✓
120W	iPhone 14 Pro	120W	27W	USB PD	✓ PD iPhone
120W	MacBook Pro 14	120W	96W	USB PD	✓ PD
140W (PD)	MacBook Pro 16	140W	140W	USB PD 3.1	✓
140W (PD)	12 Pro	140W	67W	USB PD	✓ PD
140W (PD)	Mate 40 Pro	140W	27W	USB PD	✓ PD SCP

✓ USB PD    ✓    -    ⚠ + PD    -    SCP    ✗ PD    -    OPPO VOOC

6.7.2 2

11 Pro (67W ) + 67W

0-50%			
6A	67W	15	✓
5A E-Marker	60W	17	⚠
3A	18W	45	✗
	10W	70	✗
1	67W	15	✓
3	25W	35	⚠

-    -    -    -    >60W    5A/6A

6.7.3 3

1	PD	-	Anker	-	100W / 140W USB-C PD	-	USB PD 3.0/3.1 + PPS + QC 4+ -
	Switch	-					
2	GaN	-	Anker	-	100W / 120W	2C1A / 3C1A	- USB PD 3.0 + PPS + QC 3.0/4+ -
		-	Anker 747 (150W)	-	100W (C1) / 100W (C2)	- 100W + 50W	- 65W + 45W + 40W
3		-	Baseus Ugreen	-	200W+	4-6	-
[!TIP]	GaN				100W GaN		1/3

6.8

6.8.1

USB BC 1.2	USB PD
(OVP)	5-10V +
(OCP)	MCU CC
(OTP)	/
(SCP)	
	BMS + BMS + PD
	E-Marker
	PS_RDY
	Role Swap

6.8.2

1.
2. USB-IF
3. USB-IF
4. " "
5.
6. /
7. >50°C
8. VOOC/SuperVOOC
9.
10. 100%
11. 80-90% " "
12.
13. <0°C >40°C
14.
15.

16.  
17.

6.9

USB-IF	USB Implementers Forum	USB	USB	
D+/D-	Data Plus / Data Minus	USB		
CC	Configuration Channel	Type-C	PD	
E-Marker	Electronically Marked Cable			
MCU	Microcontroller Unit			
BMS	Battery Management System			
	Direct Charging			
	Dual-Cell Battery			
	Multi-Tab			
	Handshake Protocol			
GaN	Gallium Nitride			
PPS	Programmable Power Supply	PD 3.0	20mV	
EPR	Extended Power Range	PD 3.1	28V-48V	240W
OVP	Over Voltage Protection			
OCP	Over Current Protection			
OTP	Over Temperature Protection			
SCP	Short Circuit Protection	SuperCharge Protocol		
C-to-C	USB-C to USB-C	Type-C	Type-C	
A-to-C	USB-A to USB-C	USB-A	Type-C	

6.10

6.10.1

- [USB Power Delivery Specification \(USB-IF \)](#)
- [USB Type-C® Cable and Connector Specification](#)
- [Qualcomm Quick Charge](#)

6.10.2

- **POWER-Z** USB
- **ChargerLAB KT002** PD
-

6.10.3

- [USB-IF](#)

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[!NOTE]	2023	USB-IF
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7. 6

(FAQ & Common Misconceptions)

7.1 Q:

Type-C

A:

1.

VOOC

10W

USB 2.0

3.

E-Marker

3A

65W/100W

2.

PD

7.2 Q:

Type-C

A:

Type-C

C

-9.9

+ USB 2.0

-

USB 3.2 (10Gbps) + 4K

+ 100W

-

4

40Gbps

+ 8K

+ 240W

Logo

7.3 Q:

65W

A:

USB PD

"

"

"

9V 2A "

18W

PD

5V 1A

5V 2A

7.4 Q:

A:

-

5A

4

-

USB 3.2